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EXECUTIVE SUMMARY

RESIDENTIAL HEAT LOSS CALCULATIONS NEW METHOD

J.E. Anthofer

INTRODUCTION

This report analyzes a new method of calculating heat loss for residential structures. Its aim is to establish a method which estimates a total heat loss figure very close to the actual losses of the house. Traditional methods overestimate the total heat loss, which results in the installation of oversized heating plants.

HEAT LOSS CALCULATION METHOD

This new or "X" method is a refinement of the CSA based calculation method. Adjustment in air infiltration rates and a more accurate analysis of basement heat losses are the major refinements.

HEAT LOSS RATIO

As a measure of how well the various calculation methods estimate the heat loss of a given structure, a comparison was made with a sample of homes where the actual heat loss has been measured/1/. As a comparison aid a Heat Loss Ratio (HLR) was developed and is defined below:

$$\text{For traditional Method} \rightarrow \text{HLR} = \frac{\text{HEAT LOSS BY CSA CALCULATION}}{\text{ACTUAL HEAT LOSS MEASURED.}}$$

$$\text{For "X" method} \rightarrow \text{HLR} = \frac{\text{HEAT LOSS BY "X" CALCULATIONS}}{\text{ACTUAL HEAT LOSS MEASURED.}}$$

The ratio indicates the factor by which the calculated value is greater than the actual results. Theoretically the value of this ratio should be very close to but not lower than 1.0. A value greater than 1.0 indicates the calculation method overestimated the heat loss of the house. If the calculation

job	file	date	report no.
740612-586-111	814.1(P)	March 2, 1983	82-547-K

equalled the measured value the ratio would be 1.0. An underestimated calculation of less than 1.0 is less desirable since an undersized furnace would be called for.

RESULTS

The average HLR of the new method is 1.9 versus 2.2 for the Traditional Method. Clearly the "X" method is a better estimate of the total heat loss, since the HLR is closer to 1.0. No HLR values are below 1.0 so underestimation has not occurred.

An analysis was also made in terms of grouping the sample houses according to their ages. The average HLR using the new method rises from 1.3 for 0 to 10 year old houses to 2.3 for 36 to 150 year old houses.

CONCLUSIONS

1. The new method gives a more accurate estimation of the total heat loss. The average HLR (ratio of the calculated value to the actual measured heat loss) was lower than the value calculated by traditional methods by an average of 14% (HLR 2.2 to 1.9).

2. Agreement between calculated and measured heat loss deteriorates as house age increase.

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To Mr. F.J. Kee
Director of Research

RESIDENTIAL HEAT LOSS CALCULATIONS NEW METHOD

J.E. Anthofer

A refined heat loss calculation method developed and described in this report results in a more accurate heat loss estimate. Heat Loss estimates were reduced by 14% using the refined method compared to the traditional method.

INTRODUCTION

This report analyzes a new method of calculating heat loss for residential structures. Its aim is to establish a method which estimates a total heat loss figure very close to the actual losses of the house. Traditional methods overestimate the total heat loss, which results in the installation of oversized heating plants.

At present 49 oil heated homes throughout Ontario are equipped with add-on electric heaters. Commonly referred to as Plenum Heaters, they represent the "Plenum Heater Field Trials"/1/, (PHFT) from which structural details were recorded. Analyses of data collected from these field installations give us the actual heat loss to which we compared the results obtained with our refined method.

Heat Loss Calculation Method

The new or "X" method is a refinement of the CSA based calculation method. An accurate representation of the structure's heat transmission coefficients was taken from the ASHRAE/2/ handbook. A National Research Council Building Practice Note/3/ defines the heat resistance values for below grade areas. Infiltration was set at 0.6 air changes per hour (ACH) for above grade and 0.4 ACH for below grade/4/.

The total heat loss figures for each house were compared to both the OEL results and the actual measured values. The heat loss through each part of the house was calculated separately and an assessment of which factors of the house's heat loss contributed greatest to the overall total was made. A sensitivity study indicates how small discreet changes in the components of the building effects the total heat loss.

This refined method is an intermediate step in finding the optimal method. Improvements on the CSA method and factors still requiring improvements are noted. Recommendations on how to further improve the "X" method conclude this report.

HEAT LOSS RATIO

A comparison between the traditional and the "X" methods with the measured results is made by calculating a Heat Loss Ratio (HLR). The HLR is defined as:

$$\text{For traditional Method} \rightarrow \text{HLR} = \frac{\text{HEAT LOSS BY CSA CALCULATION}}{\text{ACTUAL HEAT LOSS MEASURED.}}$$

$$\text{For "X" method} \rightarrow \text{HLR} = \frac{\text{HEAT LOSS BY "X" CALCULATIONS}}{\text{ACTUAL HEAT LOSS MEASURED.}}$$

The ratio indicates the factor by which the calculated value is greater than the actual results. Theoretically the value of this ratio should be very close to but not lower than 1.0. A value greater than 1.0 indicates the calculation method overestimates the heat loss of the house. If the calculation equals the measured value the ratio would be 1.0. An underestimated calculation of less than 1.0 is less desirable since an undersized furnace would be called for. In reality however the measured heat loss used in determining the ratios contains some inaccuracies. The most significant involves the unknown amount of wild heat gain (from appliances, people) that is included in the measured heat loss. As both the traditional and "X" heat loss calculation methods do not account for this component the HLR would be in error by up to 10% (estimated wild heat gain ≈0.5 kW).

The results of the two methods and the actual values are listed in Table I.

TABLE I

SUMMARY OF HEAT LOSS CALCULATIONS
FOR TRADITIONAL METHOD AND NEW "X" METHOD

HOUSE #	AGE (YEARS)	HOUSE TYPE	MEASURED HEAT LOSS (KW)	TRADITIONAL METHOD		"X" METHOD	
				HEAT LOSS (KW)	H.L.R.	HEAT LOSS (KW)	H.L.R.
71-01	15	2-STOREY	16.4	21.9	1.3	N.A.	--
02	20	SIDE SPLIT	8.2	21.1	2.6	"	--
03	20	BUNGALOW	14.0	19.7	1.4	"	--
04	7	2-STOREY	11.0	24.1	2.2	"	--
05	14	2-STOREY	10.0	20.3	2.0	"	--
06	21	BUNGALOW	9.0	22.2	2.5	23.8	2.6
07	30	BUNGALOW	6.3	18.6	2.9	12.4	2.0
08	9	SIDE SPLIT	9.9	12.0	1.2	11.7	1.2
09	12	2-STOREY	13.3	22.1	1.7	19.2	1.5
10	20	SIDE SPLIT	10.5	15.1	1.4	13.6	1.3
11	27	BUNGALOW	6.2	14.7	2.4	10.8	1.7
12	30	BUNGALOW	N.A.	13.8	--	13.4	--
13	141	2-STOREY	8.4	32.6	3.9	25.5	3.0
14	11	2-STOREY	8.8	17.0	1.9	12.0	1.4
15	20	BUNGALOW	6.5	14.3	2.2	15.1	2.3
16	15	BUNGALOW	4.7	11.3	2.4	13.1	2.8
17	8	BUNGALOW	6.8	12.3	1.8	11.6	1.7
18	59	2-STOREY	6.8	29.6	4.3	N.A.	--
19	19	BUNGALOW	5.7	11.5	2.0	11.4	2.0
20	21	BUNGALOW	6.2	13.1	2.1	11.8	1.9
21	4	2-STOREY	N.A.	12.7	--	10.1	--
22	22	BUNGALOW	"	20.3	--	19.0	--
23	35	2-STOREY	"	26.7	--	21.7	--
24	15	BUNGALOW	"	18.6	--	16.5	--
25	5	2-STOREY	"	13.7	--	12.6	--
26	12	2-STOREY	8.1	17.5	2.2	15.6	1.9
27	20	BUNGALOW	8.6	17.8	2.1	18.8	2.2
28	16	BUNGALOW	9.0	20.0	2.2	19.0	2.1
29	15	2-STOREY	7.0	11.5	1.6	8.9	1.3
30	30	2-STOREY	N.A.	20.9	--	25.7	--
31	35	2-STOREY	"	19.0	--	17.1	--
32	20	BUNGALOW	"	18.3	--	17.6	--
33	20	SIDE SPLIT	"	19.1	--	20.1	--
34	21	BUNGALOW	"	19.6	--	21.8	--
35	60	2-STOREY	"	20.2	--	22.9	--
36	23	BUNGALOW	8.4	17.2	2.1	13.6	1.6
37	40	2-STOREY	7.7	15.9	2.1	13.4	1.7
38	30	BUNGALOW	N.A.	17.2	--	16.7	--
39	40	BUNGALOW	10.8	23.7	2.2	22.2	2.1
40	22	BUNGALOW	7.9	22.3	2.8	20.1	2.5
41	20	BUNGALOW	7.6	N.A.	--	--	--
42	30	BUNGALOW	7.2	18.6	2.6	19.2	2.7
43	7	2-STOREY	13.7	20.5	1.5	18.3	1.3
44	33	BUNGALOW	10.1	13.1	1.3	14.6	1.4
45	31	BUNGALOW	7.4	N.A.	--	--	--
46	23	BUNGALOW	7.9	21.0	2.7	18.4	2.3
47	10	BUNGALOW	8.5	10.9	1.3	10.2	1.2
48	29	2-STOREY	N.A.	23.6	--	--	--
49	15	BUNGALOW	"	13.7	--	14.2	--
				AVERAGE H.L.R. 2.2		AVERAGE H.L.R. 1.9	

A detailed analysis of how the new method arrives at these values is performed in Appendix A.

Examining Table I the average HLR of the new method is 1.9 versus 2.2 for the Traditional Method. Clearly the "X" method is a better estimate of the total heat loss, since the HLR is closer to 1.0. No HLR values are below 1.0 so underestimation has not occurred.

HOUSE AGE

House age may be used to account for variations in heat loss. It is expected that as house age increases heat loss also increases mainly due to lower insulation standards at the time of construction.

Table II categorizes the homes according to their age groups and presents the individual HLR's along with an average.

Analysis of the entries under the 'Traditional Method' column in Table II reveals an increase in the average HLR as the house age increases. The new method exhibits a similar rise. The "X" values for average HLR are less than the corresponding traditional method's age groups.

This increase in HLR versus age may be explained by the following. As homes become older, accurate knowledge of existing insulation values decrease. Underestimated insulation levels cause calculation methods to overestimate the total heat loss.

Table II also shows a noticeable increase in the average heat loss as house age increases, as was expected.

TABLE II

HEAT LOSS RATIO BASED ON AGE OF HOMES

HOUSE AGE GROUP (YEARS)	TRADITIONAL METHOD			"X" METHOD	
	HOUSE #	HEAT LOSS (KW)	H.L.R.	HEAT LOSS (KW)	H.L.R.
0-10	71-04*	24.1	2.2	N.A.	N.A.
	-08	12.0	1.2	11.7	1.2
	-17	12.3	1.8	11.6	1.7
	-43	20.5	1.5	18.3	1.3
	-47	10.9	1.3	10.2	1.2
AVERAGE		13.9	1.6	13.0	1.3
11-20	71-01*	21.9	1.3	N.A.	N.A.
	-02*	21.1	2.6	"	"
	-03*	19.7	1.4	"	"
	-05*	20.3	2.0	"	"
	-09	22.1	1.7	19.2	1.5
	-10	15.1	1.4	13.6	1.3
	-14	17.0	1.9	12.0	1.4
	-15	14.3	2.2	15.1	2.3
	-16	11.3	2.4	13.1	2.8
	-19	11.5	2.0	11.4	2.0
	-26	17.5	2.2	15.6	1.9
	-27	17.8	2.1	18.8	2.2
	-28	20.0	2.2	19.0	2.1
	-29	11.5	1.6	8.9	1.3
AVERAGE		15.8	2.0	14.7	1.9
21-35	71-06	22.2	2.5	23.8	2.6
	-07	18.6	2.9	12.4	2.0
	-11	14.7	2.4	10.8	1.7
	-20	13.1	2.1	11.8	1.9
	-36	17.2	2.1	13.6	1.6
	-40	22.3	2.8	20.1	2.5
	-42	18.6	2.6	19.2	2.7
	-44	13.1	1.3	14.6	1.4
	-46	21.0	2.7	18.4	2.3
AVERAGE		17.9	2.4	16.0	2.1
36-150	71-13	32.6	3.9	25.5	3.0
	-18*	29.6	4.3	N.A.	N.A.
	-37	15.9	2.1	13.4	1.7
	-39	23.7	2.2	22.2	2.1
AVERAGE		24.1	2.7	20.4	2.3

* - not used in average calculation

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SENSITIVITY

A sensitivity analysis was made to determine the degree to which each component of the heat loss calculation contributes to the overall heat loss. The largest contributors are air infiltration, and outside wall area losses. Slight changes in data related to these two factors will have the greatest effect upon the total heat loss figure. Data manipulation to study sensitivity is performed in Appendix B. Table III below summarizes the more significant results.

TABLE III

Variable	Change			Effect on Total Heat Loss %
		From	To	
Ceiling and wall insulation levels	ceiling	R20	R15	+11
	walls	R8	R6	
	ceiling	R20	R10	+28
	walls	R8	R4	
Infiltration rates (air change per hour, ACH)	above grade	0.6 ACH	0.5 ACH	-6.1
	below grade	0.4 ACH	0.3 ACH	
	above grade	0.6 ACH	0.4 ACH	-12.5
	below grade	0.4 ACH	0.2 ACH	
Windows (as a percentage of total wall area)	10%		5%	- 4.7
	10%		15%	+ 4.7
	10%		20%	+ 9.4

HOUSE STYLE

The shape of the structure can greatly effect the total heat loss. For comparison, a standard total floor area of 93 m^2 or

1000 sq ft was picked. With all other data remaining constant, the house shape was altered while equally dividing the total floor area into each floor. A summary of the results is tabulated in Table IV below. The least heat loss occurs with a two storey square shape house.

This information may prove useful if a relationship can be established between house layout and heat loss.

TABLE IV

House Configuration For Total Floor Area of 92.9 m^2 (1000 ft^2)	Relative Heat Loss
square bungalow	1
rectangular bungalow	1.03
L-shaped bungalow	1.07
square 2 storey	0.89

CONCLUSIONS

1. The new method gives a more accurate estimation of the total heat loss. The average HLR (ratio of the calculated value to the actual measured heat loss) was lower than the value calculated by traditional methods by an average of 14% (HLR 2.2 to 1.9).

2. The average HLR using the new method rises from 1.3 for 0 to 10 year old houses to 2.3 for 36 to 150 year old houses.

RECOMMENDATIONS

1. A more accurate representation of the infiltration rate must be made. Estimates of the air change rate remain exaggerated. For below grade areas air infiltration is expected to be practically nil. The rate should be adjusted accordingly; as low as 0.1 ACH or 0.0 ACH. For above grade areas (including above grade basements) the rate of 0.6 ACH should be lowered to approximately 0.4 ACH. Substituting these corrections into the "X" method would result in a lower estimate of the total heat loss.

2. When attic losses were calculated, only the resistive value of the insulation was taken into account. The total insulative value of the ceiling would be better represented if roof rafters, air film, and finished ceiling gyprock were included in the calculations. This would lower the heat loss through the attic.

3. For perimeter walls, the framing studs have not been accounted for in calculating thermal resistance. Taking this studding into account would decrease heat loss in the case of poorly insulated walls or increase heat loss in well insulated walls.

4. Insulation details of older houses remain inadequate. Further tests should be conducted to determine the levels of insulation that actually exits.

5. In many cases, basement data regarding the amount of above and below grade wall area had to be estimated as only the total height of the basement wall was recorded. Actual field measurements would improve the accuracy of the heat loss estimate.

Approved:

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Submitted:

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Reviewed by:

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2. ASHRAE Handbook 1981 Fundamentals, Chapter 23.

3. Quirouette, R.L. and E.C. Scheuneman. "Estimating Energy Savings from Reinsulating Houses". Table B-2 Building Practice Note 20. Division of Building Research, National Research Council of Canada.

4. Pellini, F.G. "Adopting a Better Method of Calculating Heat Loss of Residential Structures". Minutes of Meeting. January 18, 1982.

5. "Standard for Residential Electric Heating". Canadian Standards Association. C273.1. Chapter 7. Table 13.

6. "Standard for Residential Electric Heating". Canadian Standards Association. C273.1. Chapter 7. Table 15.

APPENDIX A

"X" METHOD CALCULATION PROCEDURE

The "X" method of heat loss calculation requires that the house be broken into its component parts. The summation of the heat losses through each component will give the total heat loss of the house. House dimensions, window areas and insulation details are taken from the PHFT/1/ data sheets. A sample calculation is shown in Appendix D.

COMPONENT	AREA	HEAT TRANSMISSION COEFFICIENT		TEMPERATURE DIFFERENCE		HEAT LOSS
CEILING	m^2	$\frac{W}{m^2 \cdot \Delta C^\circ}$	x	ΔC°	=	WATTS

CONDUCTION HEAT LOSS

(a) Heat Transmission Coefficient

The Heat Transmission Coefficient (HTC) is given in:

$$\frac{W}{m^2 \cdot \Delta C^\circ} \text{ OR } \frac{BTU}{hr \cdot ft^2 \cdot \Delta F^\circ} \text{ units.}$$

The units of the final heat loss should be in watts (W) yet the dimensions of the house are given in feet (area in ft^2) and the design temperature is in degrees fahrenheit (F°). The desired HTC should be in the units of $W/m^2 \cdot \Delta C^\circ$

Given that:

$$3412 \frac{BTU}{hr} = 1000 \text{ W}$$

then:

$$1 \frac{BTU}{hr \cdot ft^2 \cdot \Delta F^\circ} \times 0.293 = 1 \frac{W}{ft^2 \cdot \Delta F^\circ}$$

and:

$$1 \frac{W}{ft^2 \cdot \Delta F^\circ} \times 0.0516 = 1 \frac{W}{m^2 \cdot \Delta C^\circ}$$

(b) Above Grade

Transmission coefficients for insulating materials and residential building construction were obtained from ASHRAE/2/.

(c) Below Grade

In the case of below grade construction, thermal resistance values were obtained from National Research Council Building Note/3/. See Appendix C.

(d) Ceiling Heights

For above grade floors and basements ceiling heights were assumed to be 2.4 m (8 feet) where not specified otherwise. For the basements it was also assumed that 0.9 m was above grade and 1.5 m below grade where heights were not specified.

AIR CHANGE RATE

The basic air change to heat loss ratio was taken from CSA standards/5/. Air change air rates were set to:

i. Above grade 0.6 air changes per hour
ii. Below grade 0.4 air changes per hour

Above grade, the CSA ratio is:

$$\frac{3.2}{0.75} \quad \frac{\text{watts}}{\#\text{ air changes}} \text{ ; per ft}^2 \text{ based on an 8' ceiling and 100°F}$$

temperature difference. For 0.6 ACH and variable temperature difference:

$$\text{HTC} = \frac{3.2}{0.75} * \frac{0.6}{100} = 0.0256 \frac{W}{ft^2\ \Delta F^\circ} = 1.32 \times 10^{-3} \frac{W}{m^2 \cdot \Delta C^\circ}$$

The basement ratio from the CSA standard is defined as:

$$\frac{2.1}{0.5} \quad \frac{W}{\#\text{ air changes}}$$

For 0.4 ACH and a variable temperature difference

$$\text{HTC} = \frac{2.1}{0.5} \times \frac{0.4}{100} = 0.0168 \frac{W}{ft^2\ \Delta F^\circ} = 8.67 \times 10^{-4} \frac{W}{m^2 \cdot \Delta C^\circ}$$

The HTC are based on an 2.4 m ceiling height. To adjust for 0.9 m above grade basement HTC (1.32×10^{-3}) was multiplied by 0.9/2.4 while basement HTC (8.67×10^{-4}) was multiplied by 1.5/2.4.

DESIGN TEMPERATURE

Design temperatures for the locations of the test homes are taken from CSA Standards/6/.

APPENDIX B

SENSITIVITY

A standard house was developed as a reference.

STANDARD HOUSE

BUNGALOW	- SQUARE
AREA	- 92.9 m^2 (1000 FT^2)
CEILINGS	
TOP FLOOR	- 2.4 m (8 FT)
BASEMENT	- 2.4 m (8 FT) - 0.9 m (3 FT) ABOVE GRADE 1.5 m (5FT) BELOW GRADE
WINDOWS	- TOP FLOOR ONLY 10% OF GROSS WALL AREA
TOP FLOOR WALL	- BRICK VENEER ON WOOD FRAME + INSULATION
BASEMENT WALL	
ABOVE GRADE	- 0.2 m (8 inch) CONCRETE BLOCK + INSULATION
BELOW GRADE	- NRCC BLDG NOTE/3/ PER ABOVE INSULATION
INFILTRATION	
ABOVE GRADE	- 0.6 ACH HTD = 0.0256
BELOW GRADE	- 0.4 ACH HTC = 0.0168
INSULATION	
CEILING	- R20 (IMPERIAL)
WALLS (TOP FLOORS & BASEMENT)	- R8 (IMPERIAL)

Component calculations were altered and their effect on the total heat loss was analyzed. The remaining factors were to be held constant through these calculations.

1. INSULATION FACTOR

STANDARD INSULATION	CEILING	R20
	WALLS (TOP FLOOR & BASEMENT)	R8

25% DECREASE	CEILING	R15
	WALLS	R6

Results in an 11% increase in the total heat loss.

50% DECREASE	CEILING	R10
	WALLS	R4

Results in a 28% increase in the total heat loss.

2. INFILTRATION RATE

STANDARD INFILTRATION RATES - ABOVE GRADE 0.6 ACH
- BELOW GRADE 0.4 ACH

INFILTRATION RATES AG 0.5 ACH - 17% DECREASE
BG 0.3 ACH - 25% DECREASE

6.1% HEAT LOSS DECREASE

INFILTRATION RATES AG 0.4 ACH - 33% DECREASE
BG 0.2 ACH - 50% DECREASE

12.5% HEAT LOSS DECREASE

3. WINDOW AREA

STANDARD WINDOW AREA - 10% TOTAL WALL AREA

i. 5% TOTAL WALL AREA (50% DECREASE)
4.7% HEAT LOSS DECREASE

ii. 15% TOTAL WALL AREA (50% INCREASE)
4.7% HEAT LOSS INCREASE

iii. 20% TOTAL WALL AREA (100% INCREASE)
9.4% HEAT LOSS INCREASE

4. MODIFYING OUTSIDE AIR FILM COEFFICIENT

1. TYPE 4A FRAME WALLS
15 MPH → STILL AIR
0.64% HEAT LOSS DECREASE

2. TYPE 4B SOLID MASONRY WALLS
15 MPH → STILL AIR
0.69% HEAT LOSS DECREASE

3. TYPE 4D MASONRY WALLS
15 MPH → STILL AIR
0.49% HEAT LOSS DECREASE

4. TYPE 4E MASONRY CAVITY WALLS
15 MPH → STILL AIR
0.59% HEAT LOSS DECREASE

5. HOUSE TYPE (SHAPE MODIFICATION)

The following calculations were performed using the reference house data shown previously. The only changes made were in reorganizing the perimeter walls in order to maintain a constant floor area as defined below.

STANDARD - BUNGALOW 92.9 m^2 (1000 FT^2) (equal length perimeter walls - square shape)

1. RECTANGULAR (BUNGALOW) 92.9 m^2 (1000 FT^2) (twice as long as wide)
2.8% HEAT LOSS INCREASE

2. L-SHAPED (BUNGALOW) 92.9 m^2 (1000 FT^2) (equal length arms)
7.1% HEAT LOSS INCREASE

3. 2-STOREY SQUARE 92.9 m^2 (1000 SQ FT^2)
11.4% HEAT LOSS DECREASE

APPENDIX C

TABLE B-2

PROVISIONAL THERMAL RESISTANCE AND CONDUCTION VALUES FOR BELOW-GRADE CONSTRUCTION IN CANADA/3/

FOR 8" CONCRETE FOUNDATION WALL

CONDITIONS	THERMAL RESISTANCE		TRANSMISSION	HTC
	m·C°/W	ft·F°hr/BTU	W/m @ T=100°F	W/ft·F°
WITHOUT INSULATION	0.8	(4.5)	70.08	0.0651
WITH INSULATION 24" BELOW GRADE 48" UNINSULATED				
R 0.70 (R4) INSUL	0.9	(5.1)	61.83	0.0574
R 1.41 (R8) INSUL	1.1	(6.2)	50.86	0.0473
R 2.11 (R12) INSUL	1.2	(6.8)	46.38	0.0431
R 3.52 (R20) INSUL	1.3	(7.5)	42.05	0.0391
INSULATION TO FOOTING				
R 0.70 (R4) INSUL	1.8	(10)	31.54	0.0293
R 1.41 (R8) INSUL	2.5	(14)	22.53	0.0209
R 2.11 (R12) INSUL	3.2	(18)	17.52	0.0163
R 3.52 (R20) INSUL	3.9	(22)	14.33	0.0133
CONCRETE FLOOR	4.6	(26)	12.13	0.0113

APPENDIX D

Memorandum To MR. F.G. PELLINI
Engineer
Utilization Section
Location or Dept KR263

Date July 7, 1982

File 814(P)

Subject Residential Heat Loss Calculations - New Method

It is important to obtain accurate results in residential heat loss calculations. Conservative estimates lead to wasteful oversizing of furnaces. This refined method estimates the various heat transmission coefficients more accurately, and yields a down sized heat loss figure. Ontario Electrical League (OEL) calculations and the new method are compared by the results listed in Table 1.

Table 1

Comparison of OEL and New Method Results

House #	Heat Loss OEL(Watts)	Heat Loss New Method(Watts)	Per Cent Diff
71-01	21863		
02	21100		
03	19693		
04	24100		
05	20304		
06	22241	23799	+7.0
07	18613	12405	-33.4
08	11982	11653	-2.7
09	22125	19222	-13.1
10	15149	13585	-10.3
11	14661	10817	-26.2
12	13773	13375	-2.9
13	32586	25526	-21.7
14	16966	11967	-29.5
15	14268	15142	+6.1
16	11310	13071	+15.6
17	12282	11578	-5.7

Table 1 (cont'd)

House #	Heat Loss OEL (Watts)	New Method (Watts)	Per Cent Diff
18	29600		
19	11545	11351	1.7
20	13107	11756	-10.3
21	12706	10090	-20.6
22	20329	18974	-6.7
23	26689	21694	-18.7
24	18619	16502	-11.4
25	13731	12585	-8.3
26	17465	15633	-10.5
27	17818	18757	+5.3
28	19982	19040	-4.7
29	11457	8891	-22.4
30	20913	25746	+23.1
31	19047	17101	-10.2
32	18315	17640	-3.7
33	19100	20122	+5.4
34	19596	21766	+11.1
35	20212	22895	+13.3
36	17245	13585	-21.2
37	15915	13424	-15.7
38	17216	16702	-3.0
39	23737	22195	-6.5
40	22309	20106	-9.9
41			
42	18211	19203	+5.4
43	20472	18258	-10.8
44	13108	14576	+11.2
45			
46	20974	18395	-12.3
47	10879	10179	-6.4
48	23600		
49	13748	14247	+3.6

On average the refined method produced lower heat loss values than the OEL procedure. Lower infiltration rates and increased accuracy using the ASHRAE/1/ heat conduction coefficients lead to these lower heat loss values.

Houses with little or no insulation showed larger values of total heat loss. At low insulation values the new method produces larger heat flows through walls and ceilings. This situation causes the new method to give a higher total heat loss figure versus the OEL results.

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Appendix

Procedure

1. Conduction Heat Loss

   a) Above grade: Transmission coefficients for insulating materials and residential building construction were obtained from ASHRAE/1/.

   b) Below grade: In the case of below grade basement construction thermal resistance values were obtained from National Research Council building note #20/2/.

2. Air Change Rate

   The basic air change to heat loss ratio is taken from CSA Standards/3/. Air change rates have been modified.

   a) Above grade: 0.6 air changes per hour.

   b) Below grade: 0.4 air changes per hour.

3. Design Temperature

   Design temperatures for the locations of the test homes are taken from CSA Standards/4/.

Assumptions

1. Basement or upper floor ceiling heights were not specified and assumed to be 8 feet.

2. Heat transmission coefficients units are:

$$\frac{W}{ft^2 \times \Delta F^\circ}; \text{ where } 1 \frac{BTU}{hr \times ft^2 \times \Delta F^\circ} \times 0.293 = 1 \frac{W}{ft^2 \times \Delta F^\circ},$$

given that $3412 \frac{BTU}{hr} = 1000$ W.

Sample Calculation

#77-35, North Bay, Design Temperature = -17°F

Indoor Design Temperature = 68°F ∴ F° = 85°F

	Area ft^2	Insulation Trans. Coeff W/ft^2 ΔF	TD ΔF°	Heat Loss W
Attic	702	(R20) $\frac{1}{20}$ x 0.293 = 0.01465	85	874
Top Floors				
Gross Outside Wall	1712			
Windows	113	(Stormed - 1 Glaze) 0.5 x 0.293 = 0.1465	85	1407
Doors	39	(Solid Wood) 0.27 x 0.293 = 0.0791	85	262
Net Outside Wall	1560	Insul=o. (R = 4.44) $\frac{0.293}{4.44}$ = 0.0660	85	8750
Infiltration				
2nd Floor	702	(0.6)(3.2)/(0.75)(100) = 0.0256	85	1528
1st Floor	702	0.0256	85	1528
Basement				
Floor	702	0.0113	85	674
Gross Outside				
Wall - AG	321			
BG	460			
Windows	27	0.1465	85	336
Doors	19	(Alum. Storm) 0.28 x 0.293 = 0.082	85	132
Net Outside Wall AG	275	(R1.82) 1/182 x 0.293 = 0.161	85	3763
BG	460	0.0651	85	2545
Infiltration AG	702	3/8 x 0.0256 = 0.0096	85	573
BG	702	(0.4)(2.1)/(0.5)(100) = 0.0163 4.3/8 x 0.0163 = 0.00876	85	523
		Total		22895

References

1. ASHRAE Handbook 1981 Fundamentals, Chapter 23.

2. "Estimateing Energy Savings From Reinsulating Houses" R.L. Quirouette and E.C. Scheuneman, table B-2, Building Practice Note 20, Division of Building Research, National Research Council of Canada.

3. "Standard For Residential Electric Heating", Canadian Standards Association, Chapter 7, table 13.

4. "Standard For Residential Electric Heating", Canadian Standards Association, Chapter7, table 15.

5. "Adopting a Better Method of Calculating Heat Loss of Residential Structures", F.G. Pellini, minutes of meeting, January 18, 1982.

April 12, 1983

Erratum - Residential Heat Loss Calculations New Method, Report #82-547-K

There are several mechanical errors in the Appendix of this report. These were introduced in the process of documenting the conversion of imperial units to metric. The results tabulated in the report were not affected.

The following corrections should be made:

a) page 10; $1 \frac{BTU}{hr \cdot ft^2 \cdot \Delta F^\circ} \times 0.293 = 1 \frac{W}{ft^2 \cdot \Delta F^\circ}$

should read: $1 \frac{BTU}{hr \cdot ft^2 \cdot \Delta F^\circ} = 0.293 \times \frac{W}{ft^2 \cdot \Delta F^\circ}$

b) page 11; $1.32 \times 10^{-3} \frac{W}{m^2 \cdot \Delta C^\circ}$

should read: $0.496 \frac{W}{m^2 \cdot \Delta C^\circ}$

c) page 11; $8.67 \times 10^{-4} \frac{W}{m^2 \cdot \Delta C^\circ}$

should read: $0.325 \frac{W}{m^2 \cdot \Delta C^\circ}$

d) page 11; (1.32×10^{-3}) should read: (0.496)

e) page 11; (8.67×10^{-4}) should read: (0.325)

f) page 16; Table B-2 column headings should read:

Conditions	THERMAL RESISTANCE		TRANSMISSION	HTC
	$m^2 \cdot C^\circ/W$	$ft^2 \cdot F^\circ hr/BTU$	W/m^2 @ $\Delta T=100^\circ F$	$W/ft^2 \cdot F^\circ$

g) page 20; same as in a).

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POOR

QUALITY

ORIGINAL